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THE URGENCY OF THE ANTHROPOCENE

Vanda de Claudino-Sales[1]

[1]Pós-Doutora em Geomorfologia Costeira, Mestrado Acadêmico em Geografia, Universidade Estadual Vale do Acaraú (UVA), Sobral/CE, Brasil.
ORCID: https://orcid.org/0000-0002-9252-0729
Email: vcs@ufc.br

Abstract

The dominant external forces controlling Earth's dynamics have been astronomical and geophysical forces during the planet's 4.5-billion-year existence. In the last six decades, anthropic forces have driven exceptionally rapid rates of change on Earth. An 'Anthropocene Equation', where the natural forces tend to zero and the anthropic forces becomes comparable to them or even superior, represented this new regime. One of the consequences of the antropogenic changes is global warming. The geographers have decided, until now, not be part of this discussion. Nevertheless, the gravity of the situation demands another attitude from geographers, to help avoids an environmental and societal global catastrophe. This paper presents reflections about these situations, having as methodology the analysis of material that discusses the theme.

Keywords: Anthropocene; Environmental Crisis; Climate Changes.

A URGÊNCIA DO ANTROPOCENO

Resumo

As forças externas que controlam a dinâmica da Terra têm sido as astronômicas e geofísicas, durante quase toda a existência de 4,5 bilhões de anos do planeta. Nas últimas seis décadas, as forçantes antrópicas êm provocado taxas de mudança excepcionalmente rápidas. Este novo regime foi representado por uma "Equação do Antropoceno", na qual a forçante antrópica se torna comparável às forçantes naturais ou até mesmo dominante em relação a elas.. Uma das consequências das mudanças antrópicas é o aquecimento global. Os geógrafos decidiram, até agora, não tomar parte ativa dessa discussão. No entanto, a gravidade da situação exige outra atitude dos geógrafos, para ajudar a evitar uma catástrofe global de caráter ambiental e social. Este artigo apresenta reflexões sobre essas situações, tendo como metodologia a análise de material sobre o tema.

Palavras-chave: Antropoceno; Crise ambiental; Mudanças climáticas.

LA URGENCIA DEL ANTROPOCENO

Resumen

Las fuerzas externas que controlan la dinámica de la Tierra han sido astronómicas y geofísicas, durante casi los 4.500 millones de años de existencia del planeta. En las últimas seis décadas, el forzamiento antropogénico ha causado tasas de cambio excepcionalmente rápidas. Este nuevo régimen fue representado por una "Ecuación de l'Antropoceno", en la cual el forzamiento natural tiende a cero y que el forzamiento antropico se vuelve comparable al forzamiento natural o incluso dominante em relacion con ellos. Una de las consecuencias de los cambios antropogénicos es el calentamiento global. Hasta ahora, los geógrafos han decidido no participar activamente en esta discusión. Sin embargo, la gravedad de la situación requiere otra actitud de los geógrafos para ayudar a prevenir una catástrofe global de naturaleza ambiental y social. Este artículo presenta reflexiones sobre estas situaciones, utilizando como metodología el análisis de material sobre el tema.

Palabras-clave: Antropoceno; Crisis ambiental; Cambios climáticos.

1. INTRODUCTION

For at least two centuries, several scientists of the most several areas of knowledge have recognized that human society has been producing significant changes in nature. Such changes have grown a lot lately that the evaluation of human influence on the environment has become consensual. This manuscript presents reflections on this situation, having as methodology the analysis of the material that discusses the topic. The second part presents elements that allow a discussion on the human influence on nature within the geography.

Paul Crutzen, the Dutch chemist who won the Nobel Prize, presented in 2002 the term Anthropocene in the Nature magazine to designate the range of time of dominant human influence in nature (CRUTZEN, 2002). The Anthropocene is the geological period in which the society has significantly altered atmospheric, biogeochemical, hydrological, and biological conditions, becoming a real geological agent (STEFFEN; CRUZTEN; MCNILL, 2007). Since then, the concept has been widely used by critics of the forms of use and occupation of geographical space, especially in Europe.

Officially, the term Anthropocene does not exist, even though it is useful. In other words, the International Commission on Stratigraphy (ICS), which is part of the scientific body of the International Union of Geological Sciences and is responsible for defining the divisions of geological time, has not yet formally adhered to the Anthropocene subdivision.

Characterizing a new geological subdivision requires not only the existence of geological deposits specific to this period but also a representative location that proves where the subdivision started. To examine such issues, the ICS created the Anthropocene Working Group (AWG) a decade ago. By the end of 2016, this group decided that Anthropocene must be considered a new geological era in the Holocene.

What makes the Anthropocene conceptualization hard for the AWG has to do with when it began. Some scientists consider that the period should date back to the first agricultural revolution, which took place 10 ka ago. Others place that Anthropocene should have begun in the Industrial Revolution of the first half of the 18th century.

However, the AWG pondered that Anthropocene should have the end of WWII as its starting date. The commission also considered that the specific geological deposits of this era would be the waste and plastic deposits on the ocean floor and in coastal and continental sedimentary areas, in addition to the carbon dioxide stored in the ice columns of the glaciers (MCGREGOR et al., 2015).

Thus, the Anthropocene officialization process by the International Union of Geological Sciences (IUGS) began. However, it does not have a final decision yet since the commission must accept the AWG results, which can take a few years. But the great and fundamental kick-off has already been made.

And what exactly is the time of existence of Anthropocene? The Anthropocene starting date demarcated by the AWG, from the end of WWII until today, is known by world scientists as the period of great acceleration.

2. DEVELOPMENT

2.1. The Great Acceleration

The Great Acceleration began at the end of WWII. The lessons learned from the war and the resulting technological advances inspired a new economic and political regime that has resumed social and economic growth, primarily led by the United States (MCNEILL, 2014).

From the environmental point of view, the Great Acceleration denotes an exponential growth of large concentrations of carbon dioxide and methane in the air, high temperatures of the land surfaces, decrease in biodiversity, acidification of the oceans, invasion of exotic species, mainly plants, in regional habitats, excessive marine fishing, loss of tropical forests, population growth, construction of large dams and the emergence of international tourism (COLVILE, 2016).

The Great Acceleration gives evidence that the Earth is heading towards a less diverse world, less forested, much warmer, and more prone to storms and disasters.

The Great Acceleration took place initially in an intellectual, cultural, political, and legal context in which the impacts caused by society on the environment counted very little in the calculations and decisions of governments, laboratories, large and small farms, and communities. But the sharp growth in society's effects on the global environment over the past 15 years has changed this context, and today there is great concern with environmental preservation. Table 1 summarizes what has become known in the literature as planetary limits or borders (ROCKSTROMET, 2009), later exposed by McNeill (2014).

The human population has grown fast and may reach 10 billion people in the next decades. Today, methane-producing cattle account for more than 1.5 billion heads. The disappearance of rainforests is releasing carbon dioxide and producing the extinction of species. Humans have used a considerable part of freshwater and explored about half of the Earth (WATERS, 2016).

Besides, fishing has removed more than 30% of primary production in resurgent oceanic areas and about 40% on continental shelves. Energy use increased 16-fold in the late 20th century, producing 160 million tons of atmospheric sulfur gas per year, more than double the natural emissions. Fertilizers have fixed nitrogen in agriculture in significant quantity compared to that in all terrestrial ecosystems. The nitric oxide produced by burning fossil fuels and biomass also exceeds natural emissions (CANFIELD; GLAZER; FALKOWSKI, 2010).

The carbonic gas in the atmosphere today – 409.8 parts per million – is 120 parts per million higher than it was before Anthropocene (NOOA, 2019). The acidification rate in the oceans is the highest of the last 300 Ma. The launch rate of carbon dioxide to the atmosphere (of the average order of 10 pentagrams, or 10 billion tons) is the largest in 66 Ma. Methane concentration in the atmosphere increased to 1,810 parts per billion in 2012, which is 2.5 times higher than in 1750. The change is extraordinary compared with natural forces and is more than double the value observed in the last 800 ka (KONHAUSER; PECOITS; LALONDE, 2009).

The extinction rate produced by human society is 10 to 100 times higher than the normal in history. Humanity is experiencing the sixth great extinction of animal and plant species, with rates growing fastly in the marine and terrestrial environments (CEBALLOS et al., 2015). Humans are modifying the biosphere structure and functioning to the extent that Anthropocene represents the beginning of the third stage of biosphere evolution. It followed the microbial phase in the Archean (3.6 Ga) and the metazoans in the Neoproterozoic (650 Ma), which denotes the first animals (BARNOSKY et al., 2012).

Table 1 – Principal types of global change caused by human activities in Anthropocene.

Global climate change due to the increase of greenhouse gases in the troposphere;
Acidification of the oceans due to the fixation of carbon dioxide in the atmosphere caused by human activities. Along with the heating of oceanic water, it represents a real threat to the vitality and productivity of marine fishing and biodiversity;
Changes in the nitrogen, phosphorus, and sulfur cycles;
Loss of biodiversity, causing change/break in ecosystems due to the loss of habitat, climate change, amongst other social pressures;
Deterioration and loss of arable land due to the exploitation, erosion, and urban/industrial expansion;
Exhaustion of freshwater reservoirs due to the reduction of aquifers, river flow, and loss of wetland;
Loss of non-renewable resources such as phosphate and rare-earth element;
Destruction of coastal landscapes and ecosystems due to the intense urban and industrial occupation;
Modification in the river courses in reason of reservoirs, hydroelectric power plant, deviation and transposition

Source: Adapted from McNeill (2014).

Besides, technological and economic advances that previously contributed to public health, given the intensity with which they interfere with the natural dynamics and amplify the human ecological spirit, are now risking it.

The temperature change rate of the Earth has been around –0.01°C/second along the past 7ka. Over the last hundred years, it has increased to 0.7°C/second, 70 times the average, and towards the opposite. Since 1970, when human influence on the climate became visible, the temperature increase rate has become 1.7°C/second, 170 times more than in Holocene. The burning of fossil fuels and agriculture have produced an increase in greenhouse gases in the atmosphere. This way, the Earth is warming up fast (IPCC, 2013; WATERS et al., 2016).

Human activity is so intense with a collective ecological spirit that it is causing global changes and ruptures, destruction, and depletions in the ecosystems and geosystems in a systematic and cumulative form. Thus, one can say that the anthropogenic forces cause more modification in the earthly system than the geophysical and astronomical ones. This way, human society is a geological agent capable of altering and controlling natural conditions (CRUTZEN, 2002; STEFFEN; CRUZTEN; MCNILL, 2007; GAFFNEY; STEFFEN, 2017).

This new functioning of the Earth, characterized by anthropogenic action as a geological element, is in the form of an equation, the Anthropocene Equation.

2.2. The Anthropocene Equation

The Earth is a natural complex composed of the geosphere, atmosphere, hydrosphere (including cryosphere), and biosphere, with approximately 4.5 Ga. Geophysical and astronomical forces have been dominant in defining the earthly dynamics since its formation. The second has influence from the Sun and Milankovitch cycle (eccentricity, obliquity, and precession). Besides, the gravitational effect of the Sun and other planets rules it. Tectonic movements, volcanism, weathering, and erosion represent geophysical forces (BERGER et al., 2016). Thus, the earthly system and its dynamics can be expressed in an equation, as follows (GAFFNEY; STEFFEN, 2017) (Equation 1):

$$\frac{dE}{dt} = f\ (A, G) \qquad (1)$$

dE means movement (change, dynamics) between two points in geographic space, dt the time interval in which this change occurs – this way, $\frac{dE}{dt}$ is the change rate of the state in the Earth-Time system – f a function, A the astronomical force, and G the geophysical force.

Therefore, the earthly dynamics in space and time are a direct function of the astronomical and geophysical forces. In other words, they control the Earth. While they give dynamics and movement to the planet, eventual processes – usually linked to the biosphere – can also cause changes in the earthly system. An example is the one associated with the production of oxygen by organisms enriching the atmosphere.

The atmosphere had no oxygen at first, which appeared around 2.5Ga when marine cyanobacteria developed photosynthesis. Thus, they started removing carbon dioxide from the air and releasing oxygen into the atmosphere. It created the ozone layer, changed the climate, produced widespread extinction of anaerobic species for which free oxygen was toxic, and allowed the emergence of new living beings, which began to breathe oxygen. Thus, humans would not exist without the biosphere intervention (KONHAUSER; PECOITS; LALONDE, 2009). The phenomenon is marked neither by geophysical nor astronomical forces, but by internal earthly dynamics, from its biosphere.

There are examples of other situations in which the biosphere has created contexts on the Earth's surface, such as the appearance of animals in the Neoproterozoic, changing the content of sedimentary deposits (LENTON; WILLIAMS, 2013). For this reason, it is relevant to add an item to the previous formula, which comes to be as follow (GAFFNEY; STEFFEN, 2017) (Equation 2):

$$\frac{dE}{dt} = f(A, G, I) \qquad (2)$$

I is the internal and biological dynamics proper of the Earth.

Some authors consider that, under the control of the current astronomical conditions, the environmental situation in the Holocene – mild temperatures from the interglacial period – would last for an additional 50,000,000 years, time for a new glacial to occur (GANOPOLSKI; WINKELMAN; SCHELLNHUBER, 2016). Since human activity is causing changes with a significant magnitude in the earthly system, it deserves individual analysis under the Earth's internal dynamics context. Thus, the Anthropocene Equation comes to be as follow (GAFFNEY; STEFFEN, 2017) (Equation 3):

$$\frac{dE}{dt} = f\ (A, G, I, H) \qquad (3)$$

H is the human society force, which is:

$$Hf(P1, P2, T) \quad P1$$

is the population, more specifically, the consumers, since the population acts differently according to the level of income, economic development, and health conditions.

$P2$ is production, considered as the creation of goods and services to suppress the needs of the human being. At this point, the exploitation of natural resources enters.

T is the technosphere, which corresponds to the set of physical structures developed by the human race – the built space, including knowledge and culture.

When analyzing the earthly system in the Great Acceleration perspective, it gets clear that human force is the dominant factor in the equation. Besides, humans seek the technosphere development to benefit everyone without destructively impacting the ecosystem.

So far, the implemented development model has proved unsustainable and exclusionary. The driving force of the expansion of the technosphere and human society obeys two logics, the culture of consumption and the pursuit of profit as the basic premise of the development.

It has produced changes in the earthly system. In the face of these facts, the Great Acceleration is reaching a critical moment. Immense challenges confront humanity today as it moves towards a growing population, excessive exploitation of natural resources, and high environmental deterioration.

Thus, the astronomical, geophysical, and dynamic forces in the Holocene are almost zero when compared to the impact of human activities over the earthly system. Finally, the Anthropocene Equation is as follows (GAFFNEY; STEFFEN, 2017) (Equation 4):

$$\frac{dE}{dt} = f(H) \qquad (4)$$
$$A, G, I \rightarrow 0$$

The permanence of the Earth in the mild interglacial conditions of the Holocene requires that the dynamics of change produced by H (human society) return to a zero level, or at least to levels comparable to the astronomical, geophysical, and dynamic forces of the Earth system (GAFFNEY; STEFFEN, 2017).

For long-term viability in a sustainable global civilization, humanity must reduce its impact on the Earth system. The alternative scenario means the continued growth of the effects, which would lead to abrupt changes, causing a collapse and dramatically substituting human force for the astronomic and geophysical ones in addition to the earthly dynamics (GAFFENEY; STEFFEN, 2017).

The ongoing human pressure on Earth in the current and growing terms means the risk of a sudden departure from the existing natural and climatic conditions, the occurrence of a glacial-interglacial cycle. It has been occurring in the Upper Quaternary, where global warming stands out, thus producing the sixth mass extinction of living species, including humans (GAFFNEY; STEFFEN, 2017).

Thus, the Anthropocene Equation indicates that not only does the Earth suffer intense degradation and extinction of species but also the end of human society, what has already happened to structured civilizations such as the Mayas and Incas. It is the current Anthropocene framework. But how geography stands in this context?

2.3. Geography and the Anthropocene

Among the sciences, geography was the one that first embraced the analysis of the human impact on nature, such a glorious achievement that renewed science. Geology, biology, and chemistry only showed concerns with environmental preservation almost a decade later. Geography keeps giving direction to the analysis of current environmental problems. However, it fails in two aspects.

Firstly, complaints still stand out over scientific research, with little scientificity and absence of alternatives for conservation and environmental recovery. Secondly, there is not an understanding of the urgency of the Anthropocene. The Anthropocene Equation indicates that the human species may collapse and disappear. Geography is not taking care of this fact, not even complaining.

Several situations indicate the urgency of the Anthropocene for geographers. Climate changes are always in privileged condition. However, in Geography, this topic is little addressed or has been poorly discussed with some exceptions (LIGHT; MARCH, 2016).

Geography, especially the Brazilian one, has contributed to the urban aspects of climate change by dealing with the urban climate system showing the changes due to the urbanization process (MONASTERY; MENDONÇA, 2010). However, few geographers have been discussing global warming, and among them, the common position is to be against the idea of its existence.

For reasons that are not completely clear, the vast majority of physical geographers, in articles, debates, personal points of view, or through simple silence, are refractory to the notion of global warming. The expression they use to justify this fact is that they are skeptical.

However, there is no room for negationism. Data from several agencies, and not only the Intergovernmental Panel on Climate Change (IPCC), provide data showing that the presence of CO2 in the atmosphere is high and caused by anthropogenic factors. The CO2 value in the atmosphere currently is 410 ppm of CO2, the highest in the last 400 thousand years (WATERS et al., 2016) (Figure 1).

The earthly temperature is increasing and has already risen 1.1ºC since the 19th century due to CO2 in the atmosphere. This increase is notorious in the last 35 years (WATERS et al., 2016). 2014, 2015, and 2016 have been the hottest years successively recorded since thermometers are marking the world temperature (GILLIS, 2017), which began in 1850 (BROHAN et al., 2006).

On the other hand, 2019 would be the second hottest year in history (NOAA, 2020). The Antarctic and Arctic ice caps are shrinking, snow coverings are reducing, ocean levels are rising, and oceans are warming up and acidifying (MCCARTHY et al., 2015). The data are expressive and do not leave many margins for doubt in the scientific environment.

Professionals who are opposed to global warming reproduce vague and unproven thoughts. Some of them recognize global warming, but it is natural because of other similar situations throughout history. Another group states that nature is magnificent, and humans cannot change the climate globally. Another group claims that it changes at a local or regional level, but not globally. However, the current reality makes these statements unsustainable.

Many geographers accept global warming but consider it natural. It is a mistake because the natural global warming occurs due to the Milankovitch cycle and solar activity.

The Milankovitch cycle occurs at intervals of 100ka a 140ka and produces glaciations and interglacial periods, as follows occurring intensely, especially in the Quaternary. However, the temperature increase resulting from this cycle is slow over geological time. If no geophysical dynamics element changes this framework, the periods of glaciation occur at intervals of 70ka and 80ka, and interglacials usually occur at intervals of 40ka to 60ka years thousand years (MILANKOVITCH, 1941; LENTON; WILLIAMS, 2013). In the processes, the temperature decreases or increases progressively, which applies to both cooling and heating.

Figure 1 – Atmospheric carbono dioxide curve before and after 1950. Source: Adapted from IPCC (2018)..

Humanity is experiencing a natural interglacial period, which began with the end of the last glaciation 12ka ago, and temperatures are already high. Researches indicate that the interglacial will last 50ka due to greenhouse gas concentration and low eccentricity (GANOPOLSKI; WINKELMAN; SCHELLNHUBER, 2016).

However, the warming now is much more acute. In the last five decades, the rate of temperature increase has become of the order of 1.7°C/sec, 170 times more than the average of the Holocene and ten times faster than the average of previous periods of the Quaternary natural global warming (CUI et al., 2011; ZEEBE; RIDGWELL; ZACHOS, 2016) (Figure 2). It seems possible that 2020 has the temperatures predicted for the end of the century (IPCC, 2018). It is fast and incomparable to natural global warming.

As for solar activities, innumerable researches, dissociated from those that point to anthropogenic global warming, reveal that the solar irradiance is decreasing in the last decades, the opposite of what has been happening with the earthly temperature (HATHAWAY, 2015). This fact is an argument for some researchers to indicate a trend towards global cooling rather than warming.

Another aspect concerns scale issues. Indeed, a frequently used question is that society would have the power to change locally and regionally, but not globally. However, with the latest data on general climatic situations, this premise is already outdated, as it is a fact that the local directly interferes with global dynamics.

Examples are the Amazonian flying rivers, which produce rainfall in central-west, southeast, and southern Brazil (NOBRE et al., 2016). Also, the Sahara dust that fertilizes the Amazon (NASA, 2015) (Figure 3), and the hurricanes hitting North America forming from Saharan hot air mass (NOAA, 2014) (Figure 4). It is not easy to separate the local and global dimensions. The geosystems have long since shown how it is all aggregated. Therefore, to insist on this premise is to insist on what is already outdated.

Negationists also say that sea levels are not rising, but islands such as the Solomon Islands, Palau, Kiribati, Seychelles, and the Maldives prove the opposite. They already have plans to relocate their populations to other countries (CLAUDINO-SALES, 2018).

Places such as Bangladesh, parts of Florida, and Venice are suffering from this rise, which may reach 60cm by 2100 (CLAUDINO-SALES, 2018). In Miami already exists avenues that get flooded every time the tide rises, and marine animals appear in the parking lots of buildings near the beach (HARRIS, 2013) (Figure 5). Thus, the considerations that there is no increase in the sea level does not match the reality today.

Another argument often used is that the oceanic water is cooling instead of warming up. However, intense hurricanes, which could be in category six if it existed, indicate that oceans are warming up. Besides, the buoys data around the world reveal upward behavior (MCCARTHY, 2015).

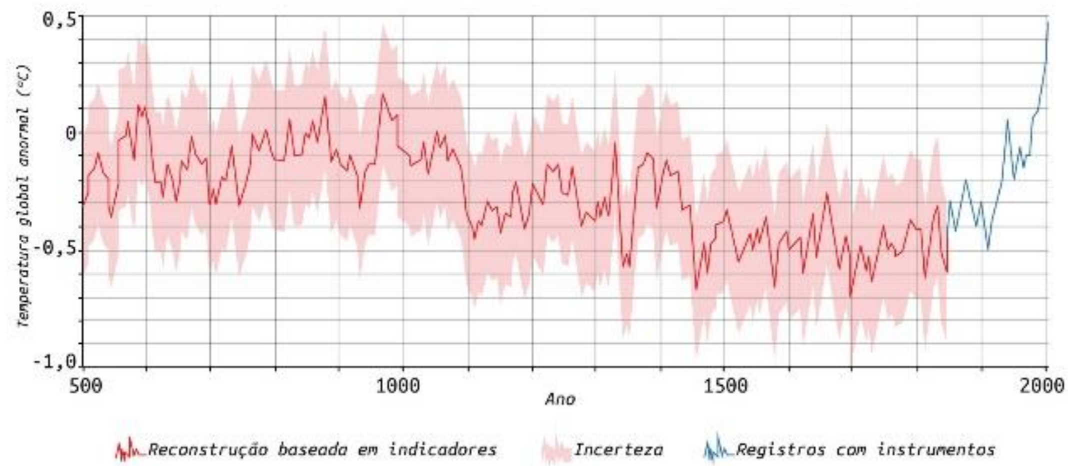

Figure 2 – Temperature anomalies in the last 1.500 years. Source: Adapted from IPCC (2018).

Figure 3 – Dust from the Sahara reaching the Brazilian Amazon. Source: NASA (2015).

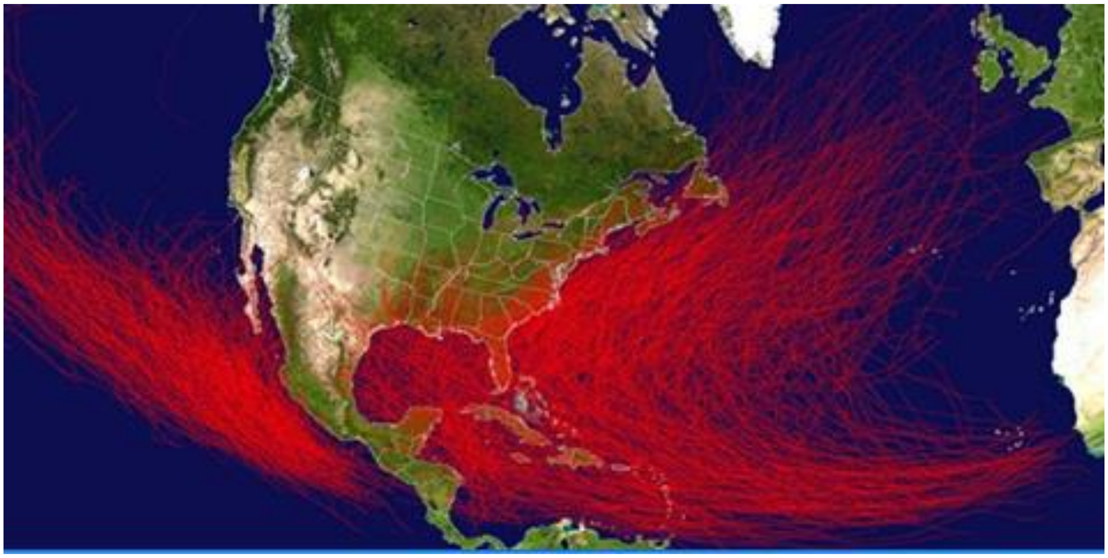

Figure 4 – African hot air masses creating climate instability and events of high magnitude such as hurricanes. Fonte: NOOA Restoration and Response Office (2014).

Figurea 5 – Presence of marine fauna in coastal building parking lots in Miami. Source: Richard Conlin for Miami Herald Newspaper (2013).

Deniers also use the idea that global warming is a way that developed countries to prevent other countries from developing. Developed countries must change their energy matrix and modify their CO2 releases. Polluting countries like China are investing heavily in solar energy to meet the dictates of international climate conventions.

For some analysts, the 2015 climate convention signed in Paris slowly meet the needs of changing patterns of economic development to avoid catastrophic global warming. However, it is partially working (ALAN, 2019; CLEMENÇON, 2016).

3. FINAL CONSIDERATIONS

Most of the geographers prefer to keep quiet in the context of global warming, claiming that they do not do specific research on the subject. However, it is not a valid argument since geography uses data from related sciences to grow. If one does not search about global warming, then he/she should follow the science and those who search about it. Researchers on this topic indicate the existence of global warming of anthropogenic origin. It is about following the current trend resulting from much research work and not about supporting unanimity.

Geographers can no longer escape such a question. If humanity does not control climate change, it will deprive more people of water, food, and housing. It will become stronger with the manifestation of waves of heat, intense hurricanes, heavy storms, floods, and devastating droughts. Therefore, the necessity is to discuss what to do concerning global warming instead of its existence.

Therefore, geographers should take over Anthropocene as a current reality to start discussing and acting. They must begin to intervene in the debate to replace the energy matrix existing based on fossil fuels for others more appropriate. It would preserve the environment aiming to change the consumption habits of developed countries and control agribusiness.

It is necessary to act again ahead of environmental problems like in a decade ago. Society needs a critical view of geographers, who can no longer stand still on these issues.

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